Observations of Near-Bottom Currents with Low-Cost SeaHorse Tilt Current Meters

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LONG-TERM GOALS

The SeaHorse TCM is a low-cost, easy to use, robust current meter based on the drag principle. Use of a large number of low-cost instruments would result in a new high spatial resolution view of the processes and to improve the ocean state prediction. The ultimate goal is to improve this technology by including expendable option with automatic data relay after deployment and to develop a global scale program of near-bottom current observations.

OBJECTIVES

The objectives are to improve the design of the instrument, evaluate its performace in comparison with other standard current meters, accumulate experience in its deployment/recovery/operation and to promote the use of such an instrument in various applications.

APPROACH

We propose to evaluate this instrument in a number of settings in comparison with standard oceanographic equipment, to demonstrate the instrument's capabilities and to analyze its performance. Specifically, we identified several organizations and researches interested and willing to try these instruments or assist in their evaluations:

1. Chris Weidman at Waquoit Bay Natural Estuary Research Reservation (WEBNERR) will assist in deploying arrays of these instruments within the bay in order to study circulation and sediment transport.
2. Steve Lentz (WHOI) agreed to deploy several Tilt Current Meters alongside his tripods carrying bottom mounted ADCPs and other instrumentation at the Marthas Vineyard Observatory.
3. Rocky Geyer (WHOI) is interested to try a very short version of this instrument to complement his project of studying circulation on tidal flats, sponsored by ONR.

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14. ABSTRACT

The SeaHorse TCM is a low-cost, easy to use, robust current meter based on the drag principle. Use of a large number of low-cost instruments would result in a new high spatial resolution view of the processes and to improve the ocean state prediction. The ultimate goal is to improve this technology by including expendable option with automatic data relay after deployment and to develop a global scale program of near-bottom current observations.

15. SUBJECT TERMS

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4. R.-S. Tseng and Y.-H. Wang (National San Yat Sen University , Taiwan) with whom PI established scientific collaboration during participation in the NLIWI project are interested to deploy these instruments off Taiwan and in South China Sea to study shelf circulation and internal wave solitons.

PI will be responsible for assembling and modifying the instruments and required moorings, will participate in deployment/recovery and will analyze the observational data. PI will also collect and analyze the instrument performance information (pertaining, for example, to bio fouling, potential data telecommunication, internal motion-driven power generation) required for future development.

WORK COMPLETED

PI received a limited amount of funding in FY09, nonetheless the project is progressing according to its original scientific plan: 1) The experiment in the Waquoit Bay will be conducted starting Nov 2009 and will last till April 2010; 2) Steve Lenz (WHOI) has deployed one instrument at the at the Marthas Vineyard Observatory. It will be recovered in January 2010; 3). Rocky Geyer (WHOI) did a test deployment in a tidal flats environment and provided data for analysis. 4). R.S Tseng (National San Yat Sen University , Taiwan) is currently maintaining a small array of instruments deployed in the Nan Wan Bay (south Taiwan).

We conducted test deployments off URI/GSO dock in about 10m depth (Fig. 1). There is a range of tidal currents of about 50 cm/s in both directions. The purpose of these tests is to calibrate several models of SeaHorse TCM of varying length 50cm, 1m, 2m long and of varying sensitivity ballasted for 50 cm/s to 10 cm/s currents against acoustic Doppler velocity measurements (SonTek/ArgonautMD). The ACM is mounted vertically, upward looking, in a stainless steel cage. The cage is supported in a vertical position by three aluminum legs. The legs are loaded with lead weights. The ACM settings are blanking distance 0.5m and varying bin size corresponding to the length of the instrument. The TCM was attached to a narrow aluminum pole extending above the cage, with the buoyant PVC pipe starting at the same level as the sampling bin of the ACM. Thus the velocity measurements were acquired essentially in the same fluid volume, above and without the interference from the cage or the tripod. The ACM were sampling every 1 sec, while TCM was programmed for sampling ranging from 1 sec to 2 min depending of the deployment duration (from 6 hours to 1 month). The deployments were conducted with the help of GSO student divers as part of a diving course taught by Mark Gustafson (a GSO diving instructor and small boat manager). The presence of divers was very helpful in ensuring that the tripod is landed properly.

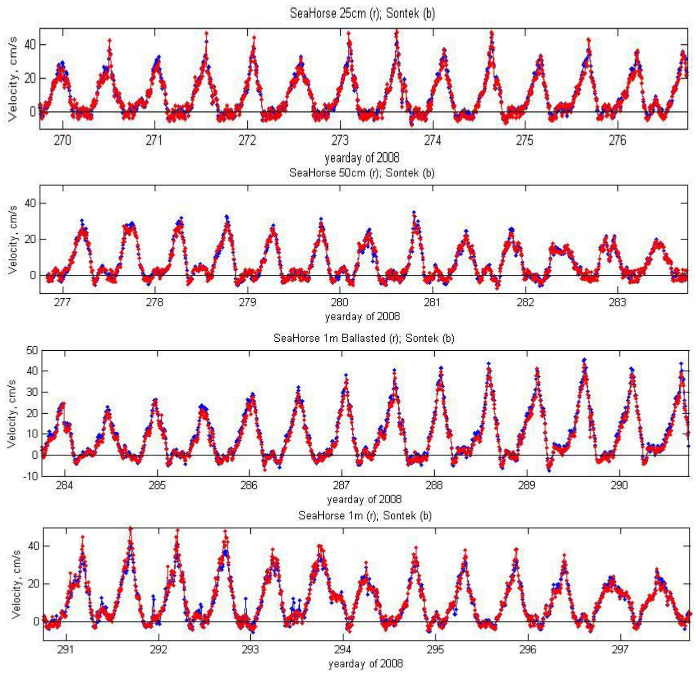

Figure 1. The calibration tests off GSO dock. The SonTek ArgonautMD acoustic current meter mounted in a tripod and SeaHorse Tilt Current Meters of different lengths (50 cm, 1m, and 2m) in preparation for deployments (right). The ArgonautMD records are shown in blue while the SeaHorse records are shown in red.

RESULTS

The calibration tests allowed us to construct an empirical relationship between the tilt angle of the instrument and the ambient velocity. The plots in Figure 1 show excellent agreement between the records. Note that the tidal current is asymmetric, predominantly southward. This is probably caused by dock pilings blocking northward flow. Note also that the tidal signal does not have a sinusoidal shape but has a sharp peak instead. This is a characteristic feature of tides in shallow waters due to nonlinear effects.

These tests allowed us to improve the empirical calibration function that relates the ambient current and the tilt angle of the SeaHorse (Fig. 2). The sensitivity of the instrument depends slightly on its length (the end effect) but more on its ballasting (or buoyancy of the pipe). Data corresponding to different instrument are marked by different colors: SeaHorse length 25cm (red), 50cm (green), 1m (blue), 1m ballasted (magenta). A rule of thumb is that the tilt of the instrument in degrees corresponds roughly to the ambient velocity in cm/s.

Another important result is the dependence of the vortex shedding regime on the ballasting on the instrument. As seen in Figure 2 small kinks in the drag curves correspond to transition from a regular Karman vortex street pattern to a chaotic pattern of eddy shedding which affects the drag coefficient (Clift 1978, Hoerner 1965). For the properly ballasted instrument the eddy shedding is reduced and the instrument performance is improved.

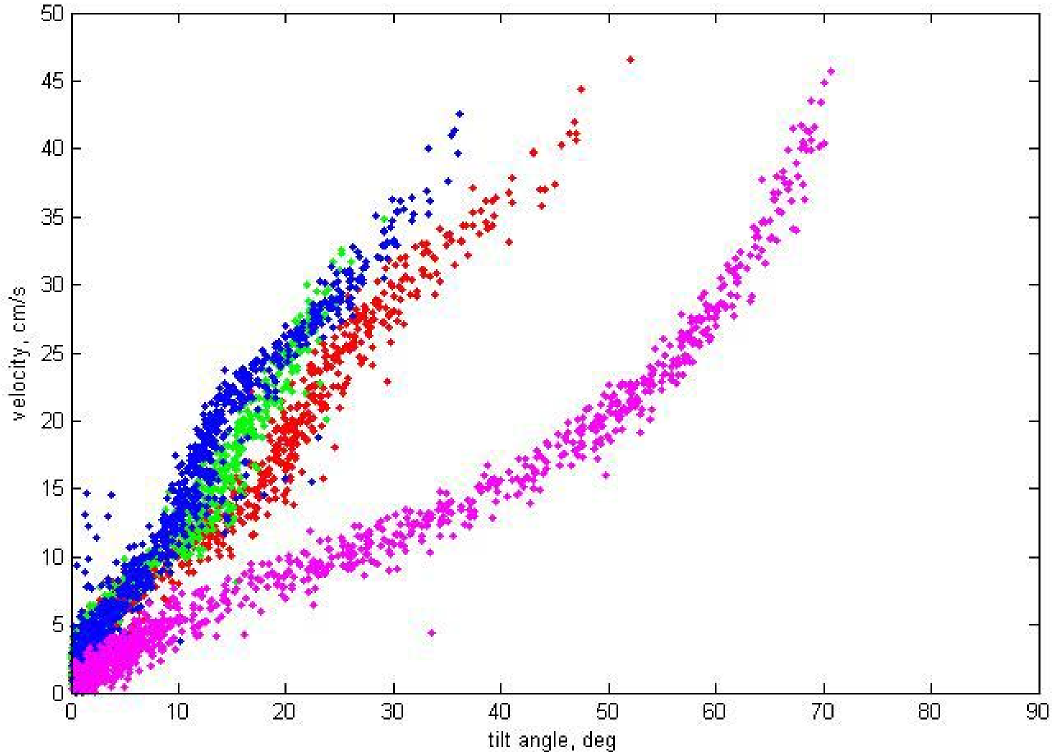

Figure 2. The empirical relationship between the ambient velocity and the tilt of the instrument: SeaHorse length 25cm (red), 50cm (green), 1m (blue), 1m ballasted (magenta).

IMPACT/APPLICATIONS

Study of the drag coefficient of this instrument has a potential future impact for other submerged applications: such as moored near-bottom buoys.

REFERENCES

Clift, R., J. R. Grace, and M. E. Weber, 1978: *Bubbles, Drops, and Particles.* Academic Press, 381pp.

Hoerner, S. F., 1965: *Fluid-Dynamic Drag: Practical Information on Aerodynamic Drag and Hydrodynamic Resistance.*